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Remarks

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I. The Present State of The Space Program

Unless you follow NASA programs closely, you may have the impression that not much is going on in space these days. You may think that because the Apollo program has ended, and we have no plans to send men to Mars, then the nation's space effort is in the doldrums, or going downhill. Such an impression would be quite erroneous.

We are proud of present accomplishments, and see the future in space as challenging and rewarding.

We have a dynamic, wide-ranging, and highly productive space effort underway for this decade, and exciting plans for the future.

Our budget is now stabilized at a generally adequate level -- about $3 billion per year, of which several hundred million per year is for aeronautics.

Recent missions, including Skylab, have been highly successful.

Our efforts to engage the Soviet Union and the West Europeans in significant cooperative space projects are bearing fruit.

And we are drawing on our space experience to assist other agencies in solving short and long-range non-space problems, including addressing energy shortage problems.

As we see it today, Apollo is already far behind us, and we have many scientific tasks to accomplish and practical benefits to win before we are ready to talk of sending men to Mars.

In this decade's NASA space program, we are working in five main areas:

1. We will continue our highly successful programs to explore throughout the Solar System with automated (unmanned) spacecraft. Pioneer 11 will fly by Jupiter in December of this year and, with a boost from Jupiter's gravity, will fly close to Saturn in September of 1979. In 1976 two Viking spacecraft will send Landers to the surface of Mars with TV cameras and other sophisticated instruments to search for signs of life.

2. We will continue our space science program to explore the Universe from automated observatories in Earth orbit. We especially want to get a better understanding of the processes by which tremendous amounts of energy are produced by quasars and other mysterious objects far out in the Universe.
3. We will emphasize the practical uses of spacecraft in Earth orbit, improving present applications satellites and developing new ones. We will launch two important experimental communications satellites this year and next, send two weather satellites into geosynchronous orbit, and follow up the excellent pioneering work of ERTS-1 with a new class of Earth observation satellites.
4. We will develop the Space Shuttle, the key to effective occupation and use of Near Earth Space. The Space Shuttle is our major effort in this decade to develop new technology and new capabilities for using space. The first orbital flight is scheduled for 1979.
5. And we will begin design and development of the larger, more advanced, more productive payloads which the Space Shuttle will launch and service in Earth orbit and, in some cases, bring back from Earth orbit.

Here I should point out that one of the most important new payloads for the Space Shuttle will be the manned Spacelab module that nine European countries are funding and developing. The Space Shuttle, when equipped with the Spacelab module, will in effect become a small space station to carry out various scientific, applications, and technology advancement missions for periods up to 30 days.

We expect to make extensive use of the Space Shuttle and the manned Spacelab throughout the 1980s and the 1990s.

The commitment of nine European countries to pay about $400 million for the development of the Spacelab module is a major achievement in international space cooperation.

Preparations for our first big cooperative effort with the Soviet Union -- the Apollo-Soyuz Test Project -- are also going well. This joint mission will be flown in July 1975. It is the last of the manned flights we have scheduled using equipment from the Apollo program. For the rest of this decade our manned space flight team will be busy with Shuttle development. We have good reason to believe that this schedule can be maintained without slippage due to either budgetary problems or technological difficulties.

I would like to talk very briefly about NASA's applications programs -- that is, about our efforts to win more practical benefits from manned and unmanned spacecraft in Earth orbit, or from the transfer of new space technology to non-space use.

At the present time NASA has applications programs in four main areas: communications, space manufacturing, Earth observations, and technology applications.

Each of these fields is broad: for example, under Earth observations we have separate programs in weather and climate, Earth resources survey, pollution monitoring, and Earth and ocean physics. To cite another example, the field of technology applications includes the use of space technology to help solve energy problems.

We are also making a strong effort to discover and define new practical uses for Earth satellites.

It might be worthwhile to take a quick look at just one of these applications areas -- space communications.

Communications Satellites

The proof of the pudding, in the applications area, is when our experimental programs lead to commercially viable programs or to programs operated by the various public service agencies of the government, such as the weather satellite program funded by the Department of Commerce.

We already have commercially viable programs in space communications. But those possibilities are just beginning to unfold. We also expect space manufacturing to be developed on a commercial scale in the 1980s. This is an area that challenges the imagination and entrepreneurial spirit of American business. Space manufacturing in zero gravity truly offers American business a new frontier.

It has been said that one main reason why this country was able to mobilize so quickly and so effectively to send men to the Moon in the Apollo program was because no well established vested interests were involved. The Moon travel field happened to be wide open.

Somewhat the same situation applied in the field of communications satellites for international communications. Comsat Corporation was able to move into a near vacuum in supplying live TV coverage from overseas.

The Soviet Union and then Canada took the lead in providing space relays for domestic communications, because there were unfilled needs in both these vast countries.

Now, as you know, important beginnings have been made in the use of space for domestic communications within the United States. Here it is not a question of filling a vacuum, but of developing a new technology that promises to greatly expand the volume of all kinds of communications and reduce costs. There is also the added advantage that the use of space relays will permit a vast expansion in domestic communications with minimum impact upon the environment.

So, in my view, the launch of Western Union's Westar satellite 13 days ago clearly opened a new era in the practical use of space. New space technology is now living -- and flourishing -- under the rules of the marketplace.

Today's commercial communications satellites are feasible only because the technology they use has been developed and demonstrated in NASA's experimental programs.

We have two more experimental satellites which will carry space communications technology a long jump forward, and open up important new opportunities for the private sector.

I am referring to our latest Applications Technology Satellite -- ATS-F -- which will be launched May 30 or soon thereafter, and to the joint U. S.-Canadian Communications Technology Satellite (CTS) which will be launched in 1975.

Among other things, these two satellites will demonstrate the feasibility of relaying television programs from synchronous orbit to low cost ground antennas -- we call them "chickenwire" antennas -- no more than 8 or 10 feet in diameter.

Western Union's Westar satellite system uses receiving antennas 32 feet in diameter.

Technologically, ATS-F and the new Canadian satellite are an intermediate step between today's satellites and the direct home broadcast satellites of the future. Their programs will be received by community stations rather than by individual set owners. Further technological advances are necessary before direct broadcasting to private homes is practical. I think private industry will be able to make these advances without further help from NASA, and I am sure they can be made on a sound commercial basis within the next 10 years. Of course, there are many other problems, besides the technological ones, that have to be solved to bring about direct TV broadcasting from space to home receivers. But I assume that I am talking right now with some of the people who will help solve these financial, business, and political problems.

ATS-F will also be used for experiments in position fixing by aircraft and ships at sea. These experiments will help refine the requirements for operational systems to be established in the 1980s.

Since the late 1960s, the United States has been negotiating with the European Space Research Organization (ESRO) and Canada on an experimental communications and navigation satellite system called Aerosat for use by the international airlines.

These negotiations reached a final stage in 1973, and the result may well be the launching of two geosynchronous Aerosat spacecraft over the Atlantic Ocean in the late 1970s.

It is thought that an operational system could be in place by the mid-1980s. Such a system would be particularly useful for air traffic control and company communications over the North Atlantic.

A similar satellite network for ships at sea would also open up new opportunities for the aerospace industry and the space communications industry.

For a number of years the world's maritime nations have thought that a communications satellite system might be the solution to the present inadequate system of communications with and between ships at sea. The United States is participating in the discussions of an international organization now considering such a system. (Inter-Governmental Maritime Consultative Organization.)

In our space applications programs, we make a direct effort to develop new technology which will have commercial or other practical uses. But useful new technology is also developed in our scientific programs simply because it is needed to accomplish the difficult missions we are undertaking.

One good example is the advances in space communications we had to make to carry out the highly successful exploration of the giant planet Jupiter by the Pioneer 10 spacecraft last December.

This remarkable spacecraft has travelled farther from the Earth and flown faster than any other man-made object. Its speed at launch had to be more than 32,000 miles per hour. That is why we were already 15 years into the Space Age before the first voyage to the Outer Planets was attempted.

Pioneer 10 flies so far from the Sun that it cannot rely on the solar cells used to provide electrical power for other spacecraft. It is the first NASA spacecraft to rely solely on nuclear energy for the electrical power needed for its communications equipment and other instruments.

This small spacecraft, weighing only 570 pounds, passed Jupiter exactly on target, with all instruments working, after a voyage of 641 days and more than 500 million miles.

It's arrival at Jupiter was so precisely timed, within a minute or two, that it was able to pass behind one of the fast moving moons of Jupiter -- the moon Io -- and carry out important occultation experiments to reveal the presence of an atmosphere on Io.

The gravity of Jupiter increased Pioneer's speed to 82,000 miles per hour. This speed will permit it to escape the Sun's gravity and sail on through interplanetary space until it is captured by the gravity of some distant star.

Pioneer 10 is still reporting on the interplanetary environment. We expect to keep in touch with it until it passes the orbit of Uranus some time in 1979. By then it will be nearly two billion miles from Earth.

Sending radio commands to Pioneer and getting back color images of Jupiter and data from the 10 other major scientific instruments aboard has been a tremendous communications achievement.

Keep in mind that Pioneer's antenna must always be pointed toward Earth for successful communications.

Keep in mind that Jupiter's radio transmitter draws only eight watts of power to begin with, and that these signals are weakened to only a tiny fraction of a watt by the time they reach Earth. [For the engineers in the audience, this tiny fraction of a watt is 10^{-12} or less. That's one quadrillionth or less.]

Keep in mind that these infinitesimal signals must be picked up by one of NASA's three big-dish antennas in California, Spain, or Australia, separated from all the radio noise of space, and amplified to readable strength.

Then consider that some of these signals, when enhanced through a special computer process at the University of Arizona, have produced color images of Jupiter with significantly more detail than can be seen through the best telescopes on Earth, and you will see why I consider Pioneer 10 one of the most remarkable creations of the Space Age.

It is obvious that learning how to get television images back from Jupiter over such long distances and such long periods of time will help us build more reliable and more productive satellites in Earth orbit in the future.

More difficult missions to explore the Outer Planets are tentatively planned for the next two decades. For example, we may put spacecraft into orbit around one of the moons of Jupiter in the early 1990s, and send a TV camera and other instruments to land on the surface of this Jovian moon.

Scientists have been delighted with the new information about Jupiter sent back by Pioneer 10.

Jupiter, it turns out, is more like the Sun than it is like the Earth. It radiates 2 1/2 times as much energy as it receives from the Sun. If Jupiter had been three times larger (in diameter) it would have become a second Sun in our Solar System.

II. The Value of New Technology

Now, before the question period, I would like to turn briefly to a subject of great interest to me personally, and a subject that should be of great interest to anyone concerned about the future of this country in general and the future of the free enterprise system in particular.

This subject is the value of new technology to our economy and our society. Specifically, I am interested in how we demonstrate the economic value of new technology over and above its intended use in the space program.

This is easy to do in the case, say, of communications satellites. It is not so easy to do in other major research and development programs such as Apollo, the program that took us to the Moon and back.

In recent years, however, several distinguished economists have been making estimates of the impact of technology on productivity.

They find that new technology does indeed have a major impact -- in quantitative terms quite comparable to that added by direct capital investment -- particularly in the years since World War II.

A recent survey of NASA's program by the Midwest Research Institute using these techniques concludes that "the $25 billion (in 1958 dollars) spent on civilian space R&D during the 1959-1969 period has returned $52 billion through 1970 and will continue to produce pay-off through 1987, at which time the total pay-off will have been $181 billion. The discounted rate of return for this investment will have been 33 percent."

Of course, this money does not come directly back to the government or to the taxpayer -- it nearly all goes to business. But the government gets a healthy share from taxes, and we all benefit from the new jobs and the new wealth and the increased strength in international trade that our R&D investment makes possible.

Let me give you a concrete example:

Between 1958 and 1961, Pratt and Whitney Aircraft attempted to develop commercial fuel cells with in-house funds. By the end of 1960, the company was ready to drop the project since the developmental problems appeared to be too complex for economical solutions. At that point, Pratt and Whitney received a NASA contract to build a 250-watt demonstration fuel cell.

Then in 1962, the company received a contract for 90 million dollars from the Johnson Space Center to develop and manufacture the fuel cells for the Apollo spacecraft power plants. This contract extended the company's fuel cell activities for five years until 1968 and caused the construction of a production plant with over 300 trained employees.

The basic fuel cell chemical process, combining oxygen and hydrogen to form electricity and water, is over 100 years old. However, the materials and technology which made this process a practical reality have required extensive development. Some of the main attractions for the fuel cell are its relatively high efficiency (above 40 percent), almost total lack of any pollution emissions, and its easy maintainability.

Following NASA's lead, partial funding was provided to Pratt and Whitney from a consortium of gas and electric utilities. The company then produced several experimental 12-kilowatt fuel cell modules which have operated almost 100,000 hours at 20 sites around the country. Based on the success of these units, Pratt and Whitney has developed a much smaller unit with the same electrical output which will be marketed this year. Although the current model is cheaper to operate than the diesel generators with which it competes for a market, further development will be required to make fuel cell generators economically feasible for widespread use.

Eleven electric utilities and the Edison Electric Institute are now funding Pratt and Whitney's research on fuel cells in the 10 to 50 megawatt range to provide peak-load power in central generating plants or for use in various locations outside the central plant. In 1972 this was a three million dollar effort, and Pratt and Whitney already has a backlog of $300 million in orders awaiting the successful demonstration of a production model.

One potential application for fuel cell generators of this size -- 10 to 50 megawatts -- would be to use the hydrogen fuel which may be produced in high temperature breeder reactor plants during periods of low demand for electricity.

This is just one of many examples I could cite to show how technology generated in the space program moves into the general economy.

The wisdom of our investment in space exploration and space applications programs at this time does not depend on this kind of economic impact. Our programs to explore the planets with automated spacecraft and to turn space-borne telescopes on the mysteries of the Universe are fully justified because of the anticipated scientific returns -- not to mention the completely unpredictable returns we are also likely to receive.

Moreover, much of our space activity in this decade and the next is being concentrated on applications programs, which by definition are expected to pay for themselves many times over in practical benefits. These programs are experimental, and of course some financial risk is involved; it is part of our mission to take reasonable risks; but it is also part of our mission, and part of our tradition, to keep the risks well within the bounds that a great nation can afford -- especially a great nation whose prosperity and general well being depend on increased productivity based on new technology.

I would like to close this part of our discussion today with a bit of dialogue from Plato's Republic, which a NASA colleague turned up recently. The first speaker is Socrates, who says to Glaucus:

"Shall we make astronomy the next study? What do you say?"

Glaucus answers: "Certainly. A working knowledge of the seasons is beneficial to everyone, to commanders as well as farmers and sailors."

And Socrates replies: "You make me smile, Glaucus. You are so afraid that the public will accuse you of recommending unprofitable studies."

A very interesting reply, considering that it was given more than 2,000 years ago.

Like Socrates, I don't think we need to point out the economic benefits that are spun off from our space efforts to justify these explorations. But in a business-oriented forum like this one, just as in the Athens of old, it doesn't hurt, either.

I thank you.